Our Ref.: 839-1028
25EA7125

# U.S. PATENT APPLICATION


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***Invention:*** DIGITIZATION OF WORK PROCESSES THROUGH THE USE OF A WIRELESS NETWORK WITH USER WEARABLE END DEVICES


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# SPECIFICATION

# DIGITIZATION OF WORK PROCESSES THROUGH THE USE OF A WIRELESS NETWORK WITH USER WEARABLE END DEVICES

[0001] This invention relates to data acquisition and control of machinery, and more particularly, to an apparatus and method for digitization of work processes using a communication network with wearable end user devices.

## BACKGROUND OF THE INVENTION

[0002] During operation of power generation equipment, several factors may likely lead to faults, thus causing breakdown of machinery. Customers' desire to service power generation equipment places added emphasis on the availability and reliability of the equipment to ensure that it is operational and available to meet periods of peak demand.

[0003] In land based gas turbines used for power generation, a compressor must be allowed to operate at a higher pressure ratio to achieve a higher machine efficiency. A variety of tests may be performed to maintain a gas turbine engine in an operating condition. Conventionally, a testing engineer may attach measuring instruments at several locations on a gas turbine to measure gas turbine operation parameters. The measured values are then compared with specified parameters to determine whether the gas turbine meets the specified parameters which enable it to be placed in operation.

[0004] Gas turbine parameters are often measured using a variety of instruments. These instruments are

used by a field engineer to measure engine parameters. Once the readings are determined to be outside of specified parameters, the field engineer communicates with a remote engineer who is responsible for controlling the various components such as valves, pumps, switches, etc. of the gas turbine. The field operations are labor intensive as multiple engineers are required to perform routine inspection and operational activities. In order to establish communication between personnel, radio or telephone links between the engineers are also required, thus further slowing down the inspection process. Access to remote services is also slow and often not in real-time, thus adding to inefficiencies.

[0005] Telephone line connections are normally used to establish corporate intranet connections or virtual private network (VPN) type of connections. The loss of information through a telephone line does not allow immediate use of applications, that are stored at a remote server, to be used at a point of service, i.e., in the field environment. The information that is stored at the remote server would have to be up-loaded off-line after completing inspections. In addition, the inspections would have to be performed by multiple engineers communicating via telephone or radio connections. Loss of communication between the engineers is a common occurrence, especially if the engineers fail to share a common communication language. Furthermore, land line installation cycles require increased installation time when compared to a mobile satellite network which may be installed in a short period of time.

[0006] Thus, there is need to overcome the inefficiencies encountered by the prior art.

## BRIEF SUMMARY OF THE INVENTION

[0007] Accordingly, this invention relates to a method and apparatus that enhances the productivity of field engineers through the combination of high bandwidth connectivity through satellite or landline connections, on-site wireless local area network (LAN) systems, and wearable computers operated by a field engineer. This combination allows digitization of work processes that in the past required multiple personnel to complete. Thus, the present invention allows a single engineer to operate the machinery (power plant or gas turbine engine), and simultaneously inspect the machinery.

[0008] Alternatively, the field engineer may measure the power plant parameters and perform tasks to manually control the power plant instead of remotely controlling the power plant by a software driven interface, such as, for example, a human machine interface. The field engineer may leverage the expertise of a remote engineer by providing the remote engineer with real-time data, video, and control connectivity in order to resolve the problem in a collaborative manner. For the purpose of this invention, a "wearable" device is defined to include systems that are adapted to be carried by a user.

[0009] The present apparatus includes at least one processor system having a controller for controlling a gas turbine. The processor system further receives

operational data from a power plant. A wireless access point/interface device is communicatively coupled to the processor system for communicating the data received from the processor system to at least one of a mobile computing system and a wearable computer. The wearable computer is adapted to be carried by a mobile user/field engineer. The controller is capable of receiving instructions from the field engineer to control the gas turbine.

[0010] The system further includes a local area network(LAN) in communication with the wireless interface device. An antenna assembly having a transceiver system is employed for transmitting and receiving signals from the wireless interface device to a remote computer server device which is communicatively coupled to the antenna assembly via a wireless communication network. The server computer includes a database for storing application data accessible by the field engineer.

[0011] Thus, the present invention provides a high bandwidth connectivity to a field engineer or other remote worker in order to enable the use of web-portal applications, stored in a remote server, at the point of service of the field engineer. Immediate access to web portal applications is provided to the field engineer at a remote installation site via two-way satellite connectivity that does not otherwise have access to a landline telephone link.

[0012] In another embodiment, the present provides a remote user, monitoring a turbine, a capability to share information with another remote user

monitoring a like turbine, such that the collaborative effort may be used to fine tune one turbine based on parameters or settings of the equivalent turbine at another remote site.

[0013] In one aspect, a system for digitization of work processes in a power plant having a gas turbine includes at least one processor system having a controller, the processor receiving power plant data, and the controller controlling the gas turbine; at least one interface device communicatively coupled to the processor system for communicating the data received from the processor system to at least one of a mobile computing system and a computer system carried by a mobile user; the controller capable of receiving instructions from the mobile user to control the gas turbine; a local area network (LAN) in communication with the at least one interface device; at least one antenna assembly having a transceiver system for transmitting and receiving signals from the at least one interface device; and a network server system communicatively coupled to the at least one antenna assembly via a wireless communication network, the server system including a database for storing application data accessible by the mobile user. The interface device preferably is a wireless access point interface, and the computer system carried by the user is a wearable computer. The access point is capable of communicating the data received from the processor system to the server computer via the LAN. The LAN comprises a wireless network, and a router.

[0014] The wireless network is preferably linked to the at least antenna assembly via an internet protocol

(IP) data interface. The system further comprises a private branch exchange network (PBX); a voice over IP (VOIP) gateway coupled to the PBX; and an ethernet interface coupled the VOIP gateway and the IP data interface. The server computer comprises at least one router; a packet switching network communicatively coupled to the at least one router; and a wide area network (WAN) coupled to the at least one router for communicating data from the server computer to the antenna assembly via an orbiting satellite. The wireless access point is capable of operating on DC power.

[0015] In another aspect, a communication network for controlling a power plant having a gas turbine, the network comprising a controller coupled to the power plant to control the gas turbine; and at least one interface communicatively coupled to the controller, the interface communicating with at least one of a mobile computing system and a wearable computer carried by a mobile user, the controller receiving instructions from one of the mobile unit and the mobile user for controlling the gas turbine.

[0016] In yet another aspect, a power plant of the type having a gas turbine, a method of controlling the power plant comprising receiving power plant data by at least one processor system having a controller; forwarding the received data to at least one of a mobile unit and a wearable computer carried by a mobile user via an interface device; inspecting the received data to determine power plant operability; instructing the controller to vary the power plant operation. The method further comprises forwarding plant data to a remote user

via a wireless communication network; receiving application data stored in a remote database system via the wireless communication network. The power plant operation is preferably varied by varying the operation of the gas turbine.

[0017] In further another aspect, a method of controlling a machine apparatus by a remote user includes receiving equipment data by at least one processor system having a controller; forwarding the received data to at least one of a mobile unit and a first wearable computer carried by a first mobile user via an interface device; inspecting the received data to determine equipment operational characteristics; forwarding the received data to a remote server via a wireless communication network; receiving, by the first wearable computer, application data stored in the remote server via the wireless communication network; and instructing the controller to vary the machine operation. The method further includes forwarding the received data from the first wearable computer carried by the first mobile user to a second wearable computer carried by a second mobile user; receiving feedback information from the second mobile user; and fine tuning the machine operation based on the feedback information. The received data is video related data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIGURE 1 is a schematic illustrating the inspection and control of power plant machinery according to the present invention;

[0019] FIGURE 2 is a high level diagram illustrating the communication network as shown in Figure 1;

[0020] FIGURE 3 illustrates a detailed version of the communication network as identified in Figure 2;

[0021] FIGURE 4 illustrates a flow-chart to measure and control a power plant machinery by a remote field engineer;

[0022] FIGURE 5 is another embodiment of the present invention, specifically illustrating a communication network.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Referring now to Figure 1, there is shown a schematic diagram illustrating the inspection and control of power plant machinery according to the present invention. Here, a power plant generally indicated at 10 includes a gas turbine engine 11. Power plant 10 is coupled to a processor system 12 such as, for example, a "human machine interface (HMI)". Application software such as, for example, Netmeeting™ available from Microsoft Corporation, may be used to communicate data between processor system 12 and the wearable computer 16 carried by the mobile user 17. Operational data from gas turbine 11 are received by the processor system 12. The processor system 12 may include a database system 13 for storing operational data and forwarding the stored data to a wireless interface unit 14 such as, for example, a wireless access point. Operational data received by the

interface unit 14 is communicated to at least one of a mobile computing unit 18 and a wearable computer 16, adapted to be carried by a mobile user 17. The wearable computer 16 is preferably of the type worn by field personnel for easy data entry. The processor system 12 includes a controller 15 for receiving instructions, from a field engineer/mobile user 17 carrying the wearable computer 16, and vary the operational parameters of gas turbine 11.

[0024] The mobile user 17 is communicatively linked to a corporate server system 52 via a network generally indicated at 38. Server 52 preferably includes a database system having a plurality of web portal applications stored therein for use by the mobile user 17. The web portal applications from server 52 are routed via a corporate router network 50 and a communication network 48, such as, for example an ATM switching network. Switched signals from communication network 48 are transmitted through router 46 via a wide area network (WAN) interface 44 to be received by network 38 via an antenna assembly 30. Signals from WAN 44 are preferably transmitted in a wireless fashion, and preferably via a satellite 40. Network 38 preferably includes a satellite transceiver 28 communicatively coupled to satellite networking equipment such as a Single Channel Demand Assigned Multiple Access (DAMA) chassis with IP data interface 26 available from TIW Systems, Inc. Further, network 38 also includes an ethernet hub 24 with a 6-port wireless LAN 22, and a 4-port voice-over-internet-protocol (VOIP) gateway 32. Gateway 32 is coupled to a private-branch exchange (PBX) 34 for communicating voice data to users at location 36.

Application data or web portal data from server 52 is transmitted to wireless interface 14 via a wireless hub 20. A mobile user 17 carrying wearable computer 16 may access the data received by the wireless interface 14. Mobile user 17 is thus capable of not only performing inspection, but also operate the power plant 10 by accessing power plant application data stored in server 52 to control the power plant 10.

[0025] Similarly, the mobile user 17 carrying wearable computer 16 may also transmit data gathered from power plant 10 to a remote user to achieve a collaborative resolution. Thus, a two-way communication between the mobile user 17 and a remote user capable of receiving information from mobile user 17 is permitted. It will be understood that the mobile user 17 is capable of performing operations to manually control the power plant 10 upon receiving power plant data via network 38.

[0026] Alternatively, voice signals from a remote user, for example, coupled to server 52 may be received at ethernet hub 24 via satellite 40 and antenna system 30. The received signals at hub 24 may be converted using a voice over internet protocol (VOIP) gateway 32 and forwarded to users at 36 via a private branch exchange unit 34. Likewise, users at 36 may also transmit voice signals to remote users communicatively coupled to system 100. It will be appreciated by one skilled in the art that the present invention need not be restricted to measuring and controlling operational characteristics of a power plant. In fact, the present invention may be applied to measure and control the

operational characteristics of any machine by a remote engineer.

[0027] Referring now to Figure 2, there is shown a high level block diagram illustrating the details of antenna and transceiver interface with wireless LAN 22 as shown in Figure 1. Figure 3 illustrates a detailed diagram of the wireless communication network shown in Figure 2.

[0028] Referring now to Figure 4, there is shown a flow-chart to measure and control a power plant machinery by a remote field engineer/mobile user 17. The mobile user 17 starts the process of inspection as identified in step 64. During step 66, after performing inspection of the power plant 10, the mobile user 17 receives power plant data in the wearable computer 16, the data being communicated through hub 14. At 68, the mobile 17 determines whether or not the received power plant data is within predetermined parameters. If the received data is within acceptable parameters, then no further adjustments of the power plant are necessary and the process stops at step 74. If the received power plant data is outside of the predetermined range, then it is determined that active control of the power plant is needed. The mobile user 17 then downloads software applications to the wearable computer 16 from corporate server system 52 via wireless network which, for example, includes components identified by numerals 38, 40 14, 44, 46, 48, 50. After downloading the software applications to wearable computer 16, user 17 performs control functions, as indicated at step 72, to adjust the operational characteristics of the power plant 10. This

process is a closed-loop process which is repeated until the measured power plant data lies within predetermined values.

[0029] Referring now to Figure 5, a second embodiment is illustrated wherein like elements as in the communication system of Figure 1 are indicated by like reference numerals preceded by the prefix "1". Here, information from wireless access point 114 is forwarded through ethernet hub 120 to a virtual private network (VPN) accelerator 54, routed through router 56 and via satellite 140 to corporate network server 52 through communication network 64. The communication network 64 includes, for example, virtual private network (VPN) tunnel 60, and a packet switching network, such as for example, internet 62, and a router 56. It will be understood that the communication network shown in Figure 5 is exemplary, and that various components may be added or removed without deviating from the spirit of the invention.

[0030] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.